PATENT SPECIFICATION

655,414

Date of Application and filing Complete Specification May 3, 1949.

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COMPLETE SPECIFICATION

Improvements in or relating to Radio Frequency Transformers

SPECIFICATION NO. 655414

INVENTOR:- EDMUND REGINALD PEACH

By a direction given under Section 17(1) of the Patents Act 1949 this application proceeded in the name of Pye Limited, a British Company of Radio Works, St. Andrews Road, Cambridge.

THE PATENT OFFICE,
11th July, 1951

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which are capable of passing a very wide band of frequencies such, for example, as band widths of 200:1 with the upper frequency limit at about 100 megacycles per second. The method of construction according to this invention, however, can be applied to radio frequency transformers which are only required to pass a narrower band of frequencies.

Wide band radio frequency transformers are required for use in radio frequency admittance bridges, for coupling thermionic valves to their loads, for matching feeders and aerials, for matching balanced or unbalanced impedances, and for various television applications. Radio frequency transformers covering a wide frequency range have previously been constructed using thin copper tape as the conductor, as disclosed in British Patent Specification No. 566,970. The high self capacitance inherent with such a winding tends to limit the frequency range of the transformer. Mechanical difficulties exist in the construction of such a transformer with electrically balanced windings where the flux from the two windings is required to cancel out.

The present invention consists in a radio frequency transformer comprising a ring core of ferromagnetic material having a cavity formed within and totally surrounded by said core in which is disposed one set of mutually coupled windings, and a second set of mutually coupled windings wound toroidally around the outside of the core. It has been found that

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which all the windings are wound on a single core, further details of this transformer being shown in Figs. 3, 4, 5 and 6;

Fig. 3 is a perspective view partly broken away showing the general arrangements of the windings on the transformer;

Fig. 4 is a sectional view on the line IV—IV of Fig. 3;

Fig. 5 is a fragmentary section on the line V—V of Fig. 4;

Fig. 6 is a fragmentary detail showing the method of winding the balanced toroidal winding of the transformer.

Fig. 1 shows a circuit diagram of a typical radio frequency bridge in which a radio frequency source is coupled to the input terminals 20, 20 connected to the primary winding A on an input transformer 21 having a secondary winding B. From one terminal of the secondary winding B a connection is taken to the sliding contact of a balancing potentiometer 22 the ends of which are connected to a pair of balanced windings C and D on a transformer 23 said windings C and D forming the ratio arms of the bridge. The other ends of the windings C and D are connected through a known impedance Z1 and an unknown impedance Z2 to the other end of the secondary winding B of the transformer 21. The second transformer 23 has a third winding E to which means for indicating balance in the bridge are connected.

Fig. 2 shows a modification of the

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Improvements in or relating to Radio Frequency Transformers

We, EDMUND REGINALD PEACH, a British Subject, and PYE LIMITED, a British Company, both of Radio Works, St. Andrews Road, Cambridge, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The present invention relates to radio frequency transformers, and more particularly to radio frequency transformers which are capable of passing a very wide band of frequencies such, for example, as band widths of 200:1 with the upper frequency limit at about 100 megacycles per second. The method of construction according to this invention, however, can be applied to radio frequency transformers which are only required to pass a narrower band of frequencies.

Wide band radio frequency transformers are required for use in radio frequency admittance bridges, for coupling thermionic valves to their loads, for matching feeders and aerials, for matching balanced or unbalanced impedances, and for various television applications. Radio frequency transformers covering a wide frequency range have previously been constructed using thin copper tape as the conductor, as disclosed in British Patent Specification No. 566,970. The high self capacitance inherent with such a winding tends to limit the frequency range of the transformer. Mechanical difficulties exist in the construction of such a transformer with electrically balanced windings where the flux from the two windings is required to cancel out.

The present invention consists in a radio frequency transformer comprising a ring core of ferromagnetic material having a cavity formed within and totally surrounded by said core in which is disposed one set of mutually coupled windings, and a second set of mutually coupled windings wound toroidally around the outside of the core. It has been found that with this arrangement a high degree of isolation between two sets of windings can be obtained.

Various embodiments in accordance with the present invention are illustrated by way of example in Figs. 1 to 6 of the accompanying drawings, in which:—

Fig. 1 is a circuit diagram of a typical known radio frequency bridge;

Fig. 2 is a circuit diagram of a modified bridge wherein a transformer in accordance with this invention is used, in which all the windings are wound on a single core, further details of this transformer being shown in Figs. 3, 4, 5 and 6;

Fig. 3 is a perspective view partly broken away showing the general arrangements of the windings on the transformer;

Fig. 4 is a sectional view on the line IV—IV of Fig. 3;

Fig. 5 is a fragmentary section on the line V—V of Fig. 4;

Fig. 6 is a fragmentary detail showing the method of winding the balanced toroidal winding of the transformer.

Fig. 1 shows a circuit diagram of a typical radio frequency bridge in which a radio frequency source is coupled to the input terminals 20, 20 connected to the primary winding A on an input transformer 21 having a secondary winding B. From one terminal of the secondary winding B a connection is taken to the sliding contact of a balancing potentiometer 22 the ends of which are connected to a pair of balanced windings C and D on a transformer 23 said windings C and D forming the ratio arms of the bridge. The other ends of the windings C and D are connected through a known impedance Z1 and an unknown impedance Z2 to the other end of the secondary winding B of the transformer 21. The second transformer 23 has a third winding E to which means for indicating balance in the bridge are connected.

Fig. 2 shows a modification of the

bridge wherein a transformer in accordance with the present invention can be used, in which the windings A, B, C, D and E, instead of being wound on separate cores, are wound on a common core in such away to reduce to a minimum the magnetic coupling between the two sets of windings on the transformers. This absence of coupling between the two transformers is indicated by drawing the core lines of the two parts of the transformer at right angles. This advantageous construction is obtained by housing the windings A and B in a cavity in the core and arranging the windings C, D and E as toroidal windings around the core.

As shown in Fig. 3 the core is built up of two rings 25 of carbonyl iron dust of commercial type which are secured face to face and provided with similar recesses 26 in their adjacent faces. The core rings can be either moulded with this recess or machined from plain rings. Housed in the cavity formed by the recesses 26 are windings 27 and 28 from which leads are brought out through an inwardly directed aperture 29. As illustrated in Fig. 3 three leads are brought out from the windings 27 and 28, one end of the windings being joined internally as indicated in Fig. 2. Each winding may either be cemented directly into the core recess or preferably the coil is wound on a special mandrel and cemented to a paper ring which supports the coil and improves the insulation between the coil and core, the preformed windings being laid into recess 26 with the paper ring between the winding and the core. When the two core rings are assembled the windings lie close together side-by-side and are surrounded by core material, whereby the leakage inductance is extremely small. When constructed in this manner and when each winding has the same number of turns, electrical balance between the two windings may be attained to a higher degree than in transformer designs where the windings are not enclosed in ferromagnetic material or are not of equal diameters, though in the embodiment shown it is not necessary that windings 27 and 28 should be so balanced since these windings form the input transformer carrying the windings A and B.

The balanced windings C and D and the winding E connected to means for indicating balance of the bridge, are wound around the core over a short distance toroidally. As indicated in Fig. 4 a metal shield 30, advantageously of copper, having its ends overlapping but not in contact is provided around the core rings, in order to reduce electrostatic coupling between the windings 27 and 28 and the toroidal windings. Wound over the shield 30 are two inter-wound windings 31 and 32 which are very tightly coupled together and wound in opposite directions and constitute the balanced windings C and D of the output transformer. In order that these windings may be correctly balanced the turns of the windings cross one another twice in each turn, each wire going alternately over and under the other. This is to equalise the inductance of the windings as the leakage inductance is a factor to be minimised. This is shown diagramatically in Fig. 6. The windings 31 and 32 are surrounded by a second shield 33 which is similar in construction to the shield 30, and provides an electrostatic screen between the windings 31 and 32 and the output winding 34 which is wound over the shield 33. A further shield 35 is wound over the winding 34 so as to reduce the external field and to reduce interference from external fields. The winding 34 constitutes the output winding E of the second transformer. As shown in Fig. 5 the shields 30, 33 and 35 are electrically connected together at 36 so that they may be earthed. The extent of the overlapping of the ends of the screens should be small in order to avoid capacitance at the overlap being sufficient to by-pass high frequencies thus causing in effect a short circuited turn.

One advantage of the construction described above is that only a single core is used thereby reducing the cost and making the apparatus more compact. Moreover round wires may be used for the windings whereas thin strip has previously been used. The external connections to the bridge can readily be made with heavy gauge strip or wire and lengthy earth returns avoided so that undesired coupling is reduced.

It has been found that with this construction a high degree of isolation between the two sets of windings can be obtained owing to the fact that the magnetic fluxes due to the windings are mutually at right angles.

Whilst there has been particularly described a balanced transformer suitable for use in a radio frequency bridge, it will be understood that the method of construction according to this invention may be applied to unbalanced transformers, and also that other modifications may be made in the details of construction without departing from the scope of the invention as defined in the appended claims.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A radio frequency transformer comprising a ring core of ferromagnetic material having a cavity formed within and totally surrounded by said core in which is disposed one set of mutually coupled windings, and a second set of mutually coupled windings wound toroidally around the outside of the core.

2. A radio frequency transformer as claimed in claim 1, wherein the ring core is formed of two parts, adapted to be secured side by side and the cavity is formed by recesses in the abutting faces of said two parts.

3. A radio frequency transformer as claimed in claim 1 or 2 wherein the ring core is made from a ferromagnetic dust material.

4. A radio frequency transformer comprising a core, consisting of two rings of ferromagnetic dust material, adapted to be secured side by side, having a set of mutually coupled windings housed in a cavity formed within said core, and at least one pair of mutually coupled windings wound toroidally around the core, the two windings of said pair of toroidal windings being interlaced and wound in opposite directions to each other.

5. A radio frequency transformer as claimed in claim 4 in which the interlaced toroidial windings cross each other twice in each complete turn round the core and so minimise the leakage inductance of the windings.

6. A radio frequency transformer as claimed in claim 4 or 5 wherein a third winding is also wound toroidally round the core and is mutually coupled to said pair of interlaced toroidal windings.

7. A radio frequency transformer as claimed in any preceding claim wherein each of the mutually coupled windings disposed within the cavity in the core is preformed, the preformed windings being positioned within the cavity and the leads from said windings passing through an aperture or apertures between the cavity and the periphery of the core.

8. A radio frequency transformer as claimed in any preceding claim wherein an electrostatic shield is provided at least between two mutually coupled windings housed within the cavity.

9. A radio frequency transformer as claimed in any preceding claim wherein an electrostatic shield is provided at least between two mutually coupled windings wound toroidally round the core.

10. A radio frequency transformer as claimed in any preceding claim wherein two mutually coupled windings housed within the cavity and/or two mutually coupled windings wound toroidally round the core are balanced windings.

11. A radio frequency transformer suitable for use in a radio frequency bridge comprising a core including two rings of ferromagnetic dust material adapted to be secured side by side and having recesses formed in their abutting faces, one pair of mutually coupled windings housed in the cavity formed by said recesses and a second set of three windings namely a pair of balanced windings and a third winding wound toroidally around the core.

12. A radio frequency transformer substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

Dated this 2nd day of May, 1949.

BARON & WARREN,
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Chartered Patent Agents.

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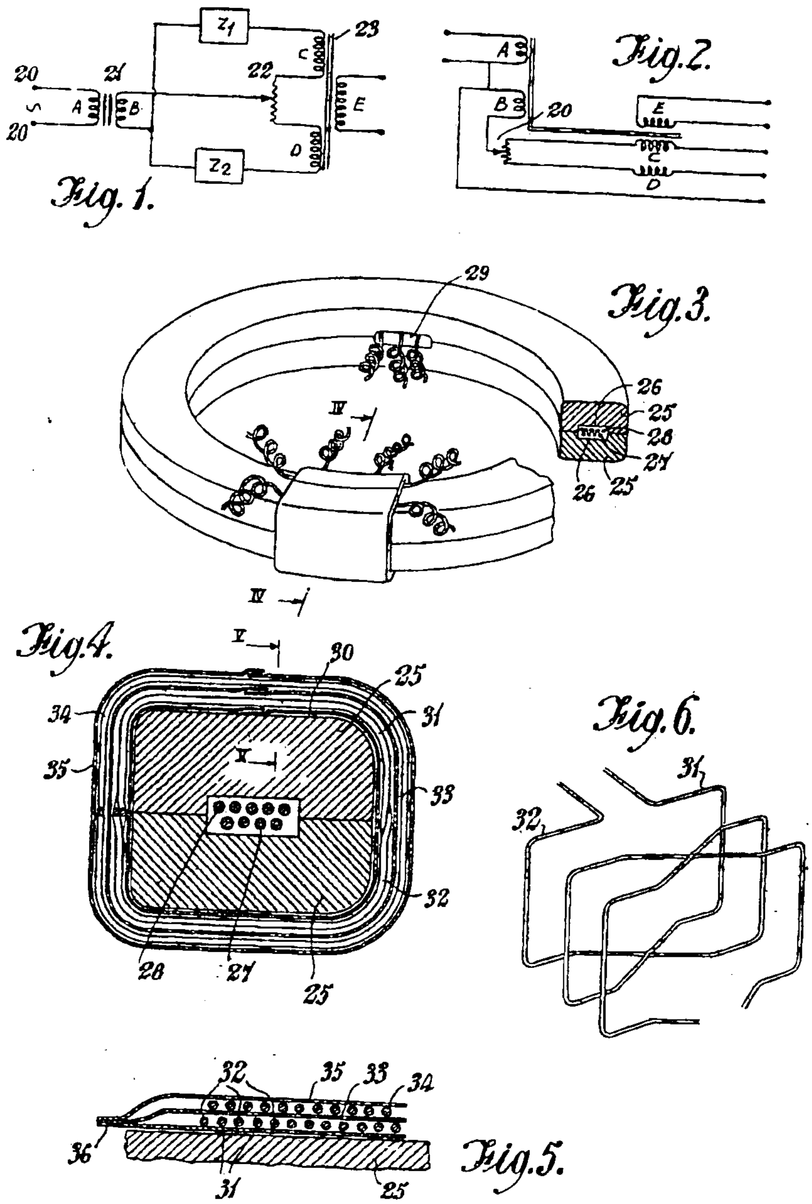
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Z1
Z2
A
B
C
D
E
S
20
21
22
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IV
V